2D Simulations of Laser Assisted Tissue Welding

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Abstract

Computer simulations of the interaction of laser light with tissue and the resulting tissue response are used in determining the optimum laser parameters to achieve strong welds. Information on the temperature and water content below the surface is needed to predict weld strength but is difficult to obtain experimentally. In order to obtain reliable depth information via simulation it is necessary that there is good agreement between simulation and experimentally measured surface conditions for a wide range of laser parameters. We give results for such a set of comparisons using our LATIS (LASer-TISsue) simulation code, where we numerical models for coupled Monte Carlo, thermal transport and mass transport. Each different tissue component is assigned initial optical, thermal and water density properties consistent with values listed in the literature. The optical properties (*i.e.* scattering, absorption and anisotropy coefficients) are modeled as dynamic functions of time and temperature. The thermal properties (*i.e.* thermal conductivity and specific heat) are dynamic functions of the temperature and water content. The water content is computed from water diffusion where losses occur by evaporation from the surface. Our simulation results show that the inclusion of water transport and evaporative losses are essential to obtain good agreement with experimentally measured surface conditions.

We simulate two procedures for welding of cuts in skin tissue. In the first procedure, solder with a dye is applied in the cut. The laser passes through the skin at a given angle of incidence and heats the solder and surrounding tissue. There is also direct absorption by the skin. Optimum laser parameters including wavelength, pulse format, and angle of incidence are found for different cut depths. In the second procedure, a topical solder/dye is used and the major strength is achieve in the bonding of the solder to the skin surface. For both procedures, the tissue is modeled with uniform layers of stratum corneum, epidermis, dermis, and fatty tissue.

Keywords: numerical modeling, tissue welding, kinetics